How do we specify a task like this?

\[ s = (x, y, z, \phi, \psi, \dot{x}, \dot{y}, \dot{z}, \dot{\psi}, \dot{\phi}, \dot{\psi}) \]

- **State:** 
  - \( a_{\text{L}} \): Main rotor longitudinal cyclic pitch control (affects pitch rate)
  - \( a_{\text{U}} \): Main rotor lateral cyclic pitch control (affects roll rate)
  - \( a_{\text{P}} \): Main rotor collective pitch (affects main rotor thrust)
  - \( a_{\text{T}} \): Tail rotor collective pitch (affects tail rotor thrust)

- **Actions (control inputs):**
- **Transitions (dynamics):**
  - \( s_{t+1} = f(s_t, a_{\text{L}}, w) \) [encodes helicopter dynamics]
  - \( w \) is a probabilistic noise model

- **Can we solve the MDP yet?**

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**CS 188: Artificial Intelligence**

**Fall 2011**

**Advanced Applications:**
Robotics / Vision / Language

Dan Klein – UC Berkeley
Many slides from Pieter Abbeel, John DeNero

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**Now: Advanced Applications**

**Inverse RL: Motivation**

- How do we specify a task like this?

[Demo: hover / autorotate]
Problem: What’s the Reward?

- Rewards for hovering:
  \[ R(s) = -\left( a_x(x - x^*)^2 + a_y(y - y^*)^2 + a_z(z - z^*)^2 \right) + a_x(\dot{z} - \dot{z}^*)^2 + a_y(\dot{y} - \dot{y}^*)^2 + a_z(\dot{z} - \dot{z}^*)^2 \]

- Rewards for “Tic-Toc”?
  - Problem: what’s the target trajectory?
  - Just write it down by hand?

Apprenticeship Learning

- Goal: learn reward function from expert demonstration
- Assume \( R(s) = w \cdot f(s) \)
- Get expert demonstrations \( s = (s_0, s_1, \ldots, s_n) \)
- Guess initial policy \( \pi_0 \)
- Repeat:
  - Find \( w \) which make the expert better than \( \{s_0, \pi_0, \pi_1, \ldots, \pi_{i-1}\} \)
  - Solve MDP for new weights \( w_i \):
  \[ \pi_i \leftarrow \text{solve}(MDP(w_i)) \]

Pacman Apprenticeship!

- Demonstrations are expert games
- Features defined over states \( s \)
- Score of a state given by:
  \[ w \cdot f(s) \]
- Learning goal: find weights which explain expert actions

Helicopter Apprenticeship?

- Demonstrations are expert games
- Features defined over states \( s \)
- Score of a state given by:
  \[ w \cdot f(s) \]
- Learning goal: find weights which explain expert actions

Probabilistic Alignment

- Intended trajectory satisfies dynamics.
- Expert trajectory is a noisy observation of one of the hidden states.
  - But we don’t know exactly which one.

Alignment of Samples

- Result: inferred sequence is much cleaner!
Final Behavior

What is NLP?
- Fundamental goal: analyze and process human language, broadly, robustly, accurately...
- End systems that we want to build:
  - Ambitious: speech recognition, machine translation, information extraction, dialog interfaces, question answering...
  - Modest: spelling correction, text categorization...

Problem: Ambiguities
- Headlines:
  - Enraged Cow Injures Farmer With Ax
  - Hospitals Are Sued by 7 Foot Doctors
  - Ban on Nude Dancing on Governor’s Desk
  - Iraqi Head Seeks Arms
  - Local HS Dropouts Out in Half
  - Juvenile Court to Try Shooting Defendant
  - Stolen Painting Found by Tree
  - Kids Make Nutritious Snacks
- Why are these funny?

Parsing as Search

Grammar: PCFGs
- Natural language grammars are very ambiguous!
- PCFGs are a formal probabilistic model of trees
  - Each “rule” has a conditional probability (like an HMM)
  - Tree’s probability is the product of all rules used
- Parsing: Given a sentence, find the best tree – search!

Syntactic Analysis

Hurricane Emily howled toward Mexico’s Caribbean coast on Sunday packing 135 mph winds and torrential rain and causing panic in Cancun, where frightened tourists squeezed into muddy shelters.
Machine Translation

- Translate text from one language to another
- Recombines fragments of example translations
- Challenges:
  - What fragments? [learning to translate]
  - How to make efficient? [fast translation search]

A Brief and Biased History

When I look at an article in Russian, say, I find that I have got to decide: Is it really written in Russian, or is it some sort of other, or is it Japanese, or is it Chinese, or is it a riddle?

Warren Weaver

Machine Translation presumably means going from machine-processible source to useful target text... In this context, there has been no machine translation...

John Pierce

Learning to Translate

<table>
<thead>
<tr>
<th>CLASSIC SOUPS</th>
<th>Sn.</th>
<th>Ig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>57. House Chicken Soup (Chicken, Celery, Potatoes, Onions, Carrots)</td>
<td>1.50</td>
<td>2.75</td>
</tr>
<tr>
<td>58. Chicken Rice Soup</td>
<td>1.85</td>
<td>3.25</td>
</tr>
<tr>
<td>59. Chicken Noodle Soup</td>
<td>1.80</td>
<td>2.95</td>
</tr>
<tr>
<td>60. Caribbean Wheat Soup</td>
<td>1.80</td>
<td>2.95</td>
</tr>
<tr>
<td>61. Tomato Clear Egg Drop Soup</td>
<td>1.65</td>
<td>2.80</td>
</tr>
<tr>
<td>62. Hot &amp; Sour Soup</td>
<td>1.15</td>
<td>2.10</td>
</tr>
<tr>
<td>63. Egg Drop Soup</td>
<td>1.10</td>
<td>2.10</td>
</tr>
<tr>
<td>64. Egg Drop Soup Mix</td>
<td>1.10</td>
<td>2.10</td>
</tr>
<tr>
<td>65. Tomato Wheat Soup</td>
<td>NA</td>
<td>3.50</td>
</tr>
<tr>
<td>66. Seafood Soup</td>
<td>NA</td>
<td>3.50</td>
</tr>
<tr>
<td>67. Crab Meat Corn Cream Soup</td>
<td>NA</td>
<td>3.50</td>
</tr>
<tr>
<td>68. Crab Meat Corn Cream Soup</td>
<td>NA</td>
<td>3.50</td>
</tr>
<tr>
<td>69. Crab Meat Corn Cream Soup</td>
<td>NA</td>
<td>3.50</td>
</tr>
</tbody>
</table>

The Problem with Dictionary Look-ups

- Top: roof
- Summit: peak | top: apex
- Head: coming directly towards one | top: end
- Lid: cover | canopy: build | Gai
- Surpass: top
- Collect: receive
- Face: lid | side | surface | aspect | top: face | flour
- Topping: top

Example from Douglas Hofstadter

Data-Driven Machine Translation

Target language corpus:
- I will get to it soon | See you later | He will do it

Sentence-aligned parallel corpus:
- Yo lo haré mañana | Hanza pronto
- Yo lo haré mañana | Hanza pronto
- Yo lo haré mañana | Hanza pronto

Machine translation system:
- Yo lo haré mañana | Hanza pronto
- Yo lo haré mañana | Hanza pronto
- Yo lo haré mañana | Hanza pronto

Model of translation:
- I will do it soon

The HMM Model

E: Thank you, I shall do so gladly.
A: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
F: Gracias, lo haré de muy buen grado.

Model Parameters
- Emissions: P(i, t) = Gracias | E1 = Thank
- Transition: P(Ai = 3 | Ai = 1)
Levels of Transfer

A Statistical Translation Model

Synchronous Derivation

A Statistical Model

Translation model components
factor over applied rules

How well are these rules
supported by the data?

Language model factors over n-grams

How well is this output sentence
supported by the data?

Synchronous Grammar Rules

$S \rightarrow \{\text{Yo lo haré después} \} \text{ ADV }

\text{I will do it later}

\text{ADV} \rightarrow \{\text{después} \text{; later}\}

Machine Translation

Example Syntax-Based Translation

[ISI MT system output]